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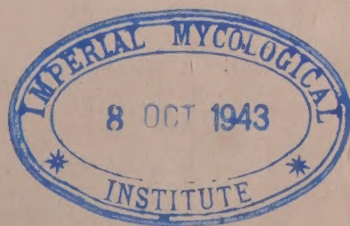
The Maine
Agricultural Experiment
Station

ORONO

BULLETIN 419

JUNE, 1943

BLUEBERRY DISEASES IN MAINE



UNIVERSITY OF MAINE
THE MAINE AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

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BULLETIN 419

BLUEBERRY DISEASES IN MAINE¹

INTRODUCTION

As pointed out by Lathrop and Nichols (20),² Merchant (27), and others, the blueberry industry of Maine is unique in American agriculture and includes one of the most valuable canning crops in Maine. Now over 75 years old (28, p. 128), the industry of this State, according to the 1940 census, produces nearly two-thirds of the total crop, by acreage, and over half of the total crop, by volume, of the United States (34).³ In 1941 the Maine pack exceeded that of any previous year in volume since records were started in 1924, and brought the growers more than a million dollars (32).

In 1925 entomological work was started (20, 29) which dealt both extensively and intensively with certain problems of blueberry growing in Maine. Studies of various horticultural problems were begun at about the same time; these were the basis of various brief reports beginning about ten years ago (8) and of several bulletins now being prepared. The horticultural investigations soon disclosed that a limiting factor in blueberry production was defoliation which presumably was due to foliage diseases. The entomological studies meanwhile demonstrated the feasibility of dusting the foliage with chemicals (19). This encouraged phytopathological studies, which were begun to see to what extent the industry could be benefited by the control, through fungicides or otherwise, of foliage diseases and, possibly, of other diseases of blueberry plants.

DISEASE SURVEY

A disease survey was necessary for distinguishing the important pathogens the control of which might give the greatest benefit. The results of a survey extending over several blueberry regions

¹ This bulletin is based, so far as Maine work is concerned, upon previous publications and photographs by Florence L. Markin, formerly assistant plant pathologist.

² Italic numbers in parentheses refer to Literature Cited, p. 415.

³ Acreage 20,136 and 31,276; yields 5,739,020 and 8,867,391 quarts; for Maine and the U. S., respectively.

of the State and through several seasons have been given largely in several publications (26; 21; 22; 23; 25; 24; 17). These results, together with pertinent references to the literature, will be given here first with respect to the different diseases encountered.

The "high-bush" blueberry, *Vaccinium corymbosum* L., is of considerable importance in the southwestern part of the State. This is the species of which varieties are cultivated extensively in some other States but which is mostly harvested in the wild state in Maine. The most common blueberry in Maine is the "low-bush" type, chiefly *V. pennsylvanicum* Lam., with a fair representation of *V. canadense* Kahm., and with other species present. Low-bush blueberries are most common in the coastal counties of the State where their growth has been stimulated by biennial or less frequent pruning through burning the aerial stems in the spring, and by some weed control. Blueberry plants are never very far from the evergreen conifers which serve as alternate hosts to some of the pathogens.

WITCHES' BROOM

Witches' broom is a disease caused by a rust fungus (*Calyptospora columnaris* Kühn) which in this region passes part of its life cycle in the leaves of balsam fir (*Abies balsamea* (L.) Mill.). The aeciospores, produced along with pycnia (30, p. 332) on the lower side of fir leaves (Plates 1 and 2), have long been known in Europe to infect *Vaccinium* plants through the leaves. From there the fungus passes to the stems where it is perennial (16, pp. 161, 185) (Plates 3 to 6). Following Fraser's first collection in North America in 1909 (11), inoculation experiments (2, pp. 231-232; 12; 15; 35) and field observations (13) showed that infection of fir leaves by sporidia from the *Vaccinium* harbored stage of the fungus in early summer might soon be followed by aeciospore production. Also, that the aeciospores caused *Vaccinium* infection which first appeared during late summer.⁴ There are no uredio-

⁴ Three species of *Vaccinium*, namely, *pennsylvanicum* (blueberry), *membranaceum* (thinleaf huckleberry), and *vitis-idaea* (cowberry or mountain cranberry) have been involved in the studies referred to in the literature, as well as several species of *Abies* including *balsamea*, *Fraseri*, and *lasiocarpa*.

spores so that unless fir is present the fungus cannot spread from one blueberry plant to another; therefore the disease on blueberry plants may be expected to be most abundant near fir trees (Plate 7).

In Maine, the disease is frequent on blueberry plants within several hundred yards of woodland. It is sometimes serious in small areas partially surrounded by woods, practically a 100 per cent infection having been observed in one field on *V. pennsylvanicum* and *V. corymbosum*. The Maine Agricultural Experiment Station in 1928 planted several varieties of *V. corymbosum* from Whitesbog, New Jersey, in a nursery at North Sedgwick. This nursery contained many other blueberry plants, mostly *V. pennsylvanicum* of native origin, was entirely surrounded by a field of native blueberries, and was about 50 feet from a wood lot. Witches' broom has not been found in New Jersey, and it is assumed that the plants from that source were free from infection when planted. In 1929, several had developed rust symptoms, and in 1930, 40 of the 71 living Whitesbog plants set in 1928 and 1929 had brooms. The infected varieties include Adams, Cabot, Harding, Pioneer, Rubel, and Sam. Varieties Katherine and Rancocas did not develop symptoms, but were represented by only two plants each and may not be immune. Infection of other plants (low-bush) in the nursery amounted to only one per cent of about 700 blueberry plants under observation. Witches' broom has been observed in Maine on *V. caespitosum* Michx., *V. canadense*, *V. corymbosum*, *V. pennsylvanicum*, *V. uliginosum* L., and *V. vitis-idaea* L. Teliospores of this rust from both high- and low-bush blueberries germinated in two days after being taken from outdoors and placed under bell jars in the greenhouse early in February. Inoculations were made on young needles of fir trees by suspending the diseased blueberry stems above them. Flecking appeared on some of the fir needles within four days but several days later had disappeared, and was not definitely seen again until the ninth to eleventh day. Pustules began to form on the twelfth day and in sixteen days 100 per cent infection had occurred. The maximum spore production was reached in two to three weeks after the appearance of pustules.

Many flecks did not develop into pustules when the trees were kept in dry air. However, when the trees were removed at intervals to humid conditions pustules continued to develop from the

flecks until as long as two months after inoculation (Plate 2). The appearance of a few pustules on fir needles until late in the summer has been noted in the field.

Blueberry plants with young tender leaves were inoculated by spraying with aeciospores from the fir. This was during April in the greenhouse. Witches' brooms began to appear in three months but discontinued growth until the advent of cool weather in October. An incubation period of three months under natural conditions would place the time of the appearance of the disease in October. Brooms do appear on previously healthy plants, out of doors, in October and it is believed that they arise from the current year's infection. Observations indicate, however, that symptoms usually appear in the springtime. This would place the incubation period of the witches' broom stage in blueberry at approximately one year.

Observations indicate that under natural conditions the period of teliospore germination in blueberry stems is quite limited, but that the aecial stage on fir may not develop for a considerable length of time after inoculation.

LEAF RUST

Leaf rust is a disease caused by a rust fungus (*Pucciniastrum myrtilli* (Schum.) Arth.) which passes part of its life cycle on hemlock (*Tsuga canadensis* (L.) Carr.). The aeciospores, produced along with pycnia (9, p. 384; 14; 15) on the lower side of the hemlock leaves (Plate 8; 9, Pl. XXIX and 6, Fig. 62), were first proved to infect blueberry leaves in Connecticut (10, p. 719; 3, p. 19; 30, p. 329). The disease was found on blueberries in the field, for the first time in that State, in 1910. Inoculation experiments showed that infection of the hemlock leaves coming from the fungus on dead, overwintered, blueberry leaves in early summer might be followed soon by aeciospore production (14; 15). In Pennsylvania, mature uredinia were observed on low-bush blueberry nine days after the aeciospores had been sown (1, p. 18).

In Maine, leaf rust on blueberries (Plate 9, A) is general in distribution and occurs at least as far as a quarter of a mile from woodlands. The rust is sometimes abundant, but has been observed to sporulate and cause defoliation only in September and later, thus lessening the damage that might have occurred had it become

more active earlier in the season. There was practically a 100 per cent infection of leaf rust on *V. pennsylvanicum* from Calais to Franklin in Washington County during the latter part of August, 1931. Leaf rust has been observed on the blueberries *V. canadense*, *V. corymbosum*, and *V. pennsylvanicum*, on *V. uliginosum*, on *Gaylussacia baccata* (Wang.) C. Koch., and, in the aecial stage, on hemlock, *Tsuga canadensis*.

POWDERY MILDEW

The powdery mildew fungus (*Microsphaera alni* var. *vaccinii* (S.) Sal.) causes a leaf-spot disease (Plate 9, B and C) that in Maine is of common occurrence and a cause of early defoliation. It is most severe on a black-fruited, waxy-leaved blueberry (*V. pennsylvanicum* var. *nigrum*) which is practically free from other diseases. *V. corymbosum* plants in York County were severely attacked but showed very striking individual differences in amount of infection. Powdery mildew has been observed, also, on *V. canadense*, *V. pennsylvanicum*, and *G. baccata*. In 1933 this disease was the most abundant and destructive foliage disease of blueberries in Maine. Its prevalence in any one season may vary greatly from one clone to another of the wild low-bush blueberry. Similarly, cultivated high-bush blueberry varieties differ much in susceptibility to powdery mildew in Massachusetts (5).

RED-LEAF DISEASE

A leaf-reddening disease caused by one or more species of the fungus *Exobasidium* has been known for some time in Europe on *Vaccinium* (16, p. 185; 18; 31, p. 11). In Maine this disease is widely distributed but has not been observed to be of such frequency on blueberries as to cause serious loss. Infected leaves are very conspicuous in June and early July because of their brilliant red color. At about that time white masses of mycelium and spores are produced on the under surfaces of infected leaves (Plate 10). Infected plants are defoliated soon after spore production (Plate 11). Leaf infection, however, continues throughout the season. In addition to leaf infection, hypertrophy of blossoms, small fruits and twigs has been observed on the huckleberry, *G. baccata*. *Exobasidium*

has been observed on the following plants: *V. canadense*, *V. corymbosum*, *V. pennsylvanicum*, *V. vitis-idaea*, *Andromeda glaucophylla* Link, *G. baccata*, and *Rhododendron canadense* (L.) B.S.P.

SCLEROTINIA SHOOT-BLIGHT AND FRUIT-ROT

A species of the fungus *Sclerotinia* causes a shoot blight (Plate 12) that appears first in a monilial stage on leaves and progresses into the stems, frequently destroying them to the ground, and that also causes a hard rot of the fruits. The blight was so severe in 1929 that there were areas four or five feet in diameter in which all stems were destroyed. Sclerotial fruits were frequently observed during July but have not been noted to persist after ripening time as they do on cranberries. The blight occurred during May and early June in 1929, but was rarely observed in 1930. The difference in seasonal occurrence may be correlated with weather conditions in spring. These observations agree with those of workers on cranberry diseases, who have noted that twig blight occurred during cold, wet weather in May such as occurred in Maine in the spring of 1929. May and early June of 1930 were dry and warm.

The disease has been observed on *V. canadense*, *V. corymbosum*, and *V. pennsylvanicum*. Only the fruit-rot stage has been observed on *V. macrocarpon* Ait. This disease as "mummy berry" is the most harmful disease of cultivated blueberries in Massachusetts (4, p. 16).

BOTRYTIS BLOSSOM-BLIGHT AND FRUIT-ROT

A Botrytis blossom-blight which was very common in 1930 appeared during a week of foggy, warm weather in late June. The fungus was very destructive on blossoms and small fruits, killing twig tips, leaves, and even stems. Infection appeared to commence in the corolla, from where it progressed downward through the point of attachment of the corolla into the fruit. Observations indicate that the disease may be correlated with poor pollination because the corollas of unpollinated blossoms persist, thus favoring the advancement of the fungus into the fruits. Botrytis sporulates on occasional shrunken berries during the summer. The

blight has been observed on *V. canadense*, *V. corymbosum*, and *V. pennsylvanicum*.

OTHER LEAF AND TWIG DISEASES

Calcium arsenate dust is being used for blueberry maggot control. It was noticed that where a very heavy coating of the dust had been applied accidentally, severe burning of foliage resulted. The symptoms are marginal browning, and circular to irregular spots, some with concentric rings. Plants were defoliated and fruits shrunken at harvest time. Arsenical injury might be confused with leaf-spots of pathogenic origin but the former was found on all kinds of plants present which would likely not have been the case had the injury been due to a pathogen.

A brown leaf-spot (Plates 13 and 14) was sparse in 1931 in eastern Maine, but was widespread and very destructive in some areas in central and southern sections of the State on low-bush blueberries. The brown leaf-spot (*Septoria* sp.) in 1932 nowhere caused the complete destruction of foliage that it had in 1930 and 1931 in some areas in south central Maine. This fungus has shown a decided preference for the leaves of new succulent shoots in natural field infections. The brown leaf-spot in 1933 was less severe in south central Maine than previously observed, and of greater prevalence and severity farther northeast, namely, in Washington County.

Phomopsis twig blight, caused by the fungus *Diaporthe vaccinii* Shear, occurs in Massachusetts and other States on high-bush blueberries (36). According to Stevens (33), this disease is apparently associated with a weakened condition of the bushes due to insufficient drainage. The disease appears first on the smaller twigs and from them extends into the larger branches killing the branches and occasionally the entire bush. The disease apparently progresses all summer with the result that the branches are often killed late in the season after the next year's buds have been formed. This gives the bushes the appearance of having been winterkilled. According to Wilcox (37; 38) the fungus may attack tender tips and grow down to older branches and girdle them, or may attack the bark of stems and roots directly, causing localized lesions, or may produce spots on leaves.

Another species of the fungus *Phomopsis* causes galls (7; 4, pp. 17-18) on high-bush blueberries. Species of the fungi *Helminthosporium*, *Melanospora*, *Pestalotzia*, *Sphaeropsis*, *Dothiorella*, and *Alternaria* have been reported on the high-bush blueberry by Wilcox (37).

DISEASE PREVALENCE BY SEASONS

In Maine in 1929 and 1930 leaf rust was general and sometimes abundant and caused no defoliation until in September. Powdery mildew was common and caused early defoliation. As previously noted, witches' broom is perennial and is common near fir trees, red-leaf disease is widely distributed but not abundant and was more common in 1930 than in 1929, Sclerotinia was much less common in 1930 than in 1929, and Botrytis became common in 1930.

In 1931 leaf rust, powdery mildew, and a brown leaf-spot were outstandingly important. The brown leaf-spot was sparse in eastern Maine, but was widespread and very destructive in some areas in central and southern sections of the State on low-bush blueberries. Leaf rust and mildew were common on both huckleberries (*Gaylussacia* spp.) and blueberries; the former was the more abundant and important of the two diseases. There was practically a 100 per cent infection of leaf rust on *V. pennsylvanicum* from Calais to Franklin in Washington and Hancock Counties during the latter part of August. Defoliation commenced early in July in regions where leaf rust and mildew were prevalent and almost all the leaves of plants growing in heavily infected areas had fallen by picking time. Berries on defoliated plants, instead of ripening, became shrunken and dropped off. The results of fungicidal treatment of plants in heavily infested areas are discussed below. The red-leaf disease increased somewhat, but remained unimportant, and Sclerotinia was sparse.

In 1932 there was less damage from foliage diseases than in 1931. The red-leaf disease increased.

In 1933 the losses from foliage diseases were comparatively moderate except in the Frankfort to Waldoboro region, where they were heavier than usual. Powdery mildew was the most abundant and destructive, leaf rust was less common than usual, and the

brown leaf-spot decreased in south central Maine while increasing in Washington County, in the eastern part of the State.

Heavy defoliation of blueberry plants and dropping of fruits were important in 1934. Undoubtedly much of the defoliation was caused by foliage diseases such as mildew and rust, but the situation was possibly aggravated by other conditions including dry weather during spring and midsummer. In 1934 in Washington County a ten-day period of heavy rains during mid-June resulted in severe infections of the blueberry leaves by fungi. The diseased leaves fell rapidly during the dry period of late July and early August, ripening of fruit was delayed, and there was an unusual shrinkage of the fruits.

Disease symptoms in these localities were not typical in 1935, probably because of the drought, and were confusing. The spots were less distinct and less colorful, and were marked by the lack of spore production in leaf rust and mildew and by the lack of the superficial white mycelial growth of powdery mildew. A brown leaf-spot seemed to be of increasing importance and caused earlier defoliation than some other diseases.

DISEASE CONTROL WITHOUT FUNGICIDES

Pruning of high-bush blueberry plants for the removal of witches' broom branches in 1930 reduced the percentage of infected bushes by half (21, 22). Pruning is recommended in Massachusetts for the control of *Phomopsis* twig blight (4, p. 16).

Eradication of the largest fir trees near a Maine nursery of the susceptible high-bush blueberries in 1931 resulted in a great reduction of new infection occurring in 1932 compared to that of preceding years (22). Low-bush plants with witches' broom can be effectively destroyed with fuel oil and other weed killers (21). The removal of wild high-bush blueberries around plantations and of mummied berries in the plantation is recommended in Massachusetts for the control of *Sclerotinia* fruit rot (4, p. 16).

In Maine, the usual field burning did not eliminate the systemic form of the red-leaf disease, though controlling the disease to some extent (22). Burning does not control witches' broom (Plate 4). Burning often reduces for a time the prevalence of leaf spots (23).

Reference has already been made to differences between high-bush varieties and between low-bush clones in susceptibility to powdery mildew.

DISEASE CONTROL WITH FUNGICIDES

EXPERIMENTS IN 1931

In 1931 (21), blueberry plants responded well to certain fungicidal treatments in an area where foliage diseases, particularly leaf rust and mildew, were abundant. With copper-lime dusts there were increases in yield, over the untreated checks, in amount from 200 to well over 320 per cent. The increase with lime sulphur was over 50 per cent and with Bordeaux mixture somewhat more.

Where there was only a light infection of foliage diseases, the copper-lime dusts increased the yield from 25 to 40 per cent while there was little change in yield with lime sulphur and Bordeaux mixture. Although Bordeaux mixture gave good fungicidal control, it was found to be injurious to blueberry plants in all of six tested combinations of copper sulphate and lime. It increased the yields only where there were heavy infections; otherwise the detrimental effects from the fungicide were great enough to offset any benefits derived from disease control. On some plots, Bordeaux mixture even stunted the plants to the extent that there was a reduction in yield.

Bordeaux mixture controlled *Sclerotinia* twig blight. It and the copper-lime dusts prevented arsenical burning of leaves.

The use of protective fungicides resulted in cleaner foliage and, also, a retention by the plants of most of their leaves until late in the fall. Studies showed that the yield and the number of fruit buds were directly related to the number of leaves per stem. Furthermore, the size and number of berries per stem were favorably influenced by increased foliage.

EXPERIMENTS IN 1932

In 1932 (22), plots treated with copper-lime dusts again gave the greatest increases in yield over that of untreated plots. Whereas, in 1931, the maximum difference in favor of treatment was as

much as 320 per cent, in 1932, in the same field, the greatest increase in yield on treated plots was only 70 to 80 per cent. Two applications of a commercial preparation, Oxo-Bordeaux, gave better results than five different strengths of home-mixed Bordeaux and than copper cyanamid all used with a fish oil adhesive. Sulfur and technical copper carbonate dusts gave unexpected increases in yield that may not have been due to their fungicidal properties. The experiments indicated that thorough coverage of foliage with fungicides during or at the close of the blossoming period, when the leaves were still developing, was important in disease control. Later applications were beneficial but not nearly as satisfactory.

Records were taken from individual stems from various plots for the purpose of obtaining more reliable information on the effect of disease control on the plants than can be obtained from plot yield records (23). Leaf counts were taken on the same stems late in July, before defoliation, and again at harvest time the last of August. Analysis of data obtained in 1932 shows the following relationships between plant parts, and gives the following relationships expressed as coefficients of correlation, r :

Number of leaves	early vs. yield	0.73 ± 0.07	
" " "	at harvest vs. yield	0.84 ± 0.05	
" " "	early vs. number of berries harvested		0.56 ± 0.11
" " "	at harvest vs. number of berries harvested		0.72 ± 0.08
" " "	early vs. size of berries	0.56 ± 0.16	
" " "	at harvest vs. size of berries	0.72 ± 0.08	
" " "	berries vs. size of berries	0.49 ± 0.12	
" " "	yield	0.92 ± 0.03	
Yield vs. size of berries		0.78 ± 0.06	
Number of leaves	early vs. number of fruit buds formed	0.78 ± 0.06	
" " "	at harvest vs. number of fruit buds	0.66 ± 0.09	

Odds were highly significant for all except the third, fifth, and seventh. The following conclusions can be drawn:

1. Number of berries, number of leaves especially at harvest, and size of berries are factors which bear a very definite relationship to yield.

2. The number of leaves retained to harvest was generally somewhat more important than the number of leaves developed

early in the season, in affecting yield and number and size of berries harvested.

3. The number of fruit buds formed was naturally more directly related to the number of leaves present at time of bud formation (July) than to the number of leaves at harvest.

A sufficient amount of copper-lime dust to give control of foliage diseases did not upset the relationships of the above factors to one another, and by the prevention of defoliation resulted in increases in yield and to some extent in number of fruit buds formed.

EXPERIMENTS IN 1933

Copper-lime dust containing 25 per cent monohydrated copper sulfate to 75 per cent hydrated lime was used in the 1933 experiments (23) unless otherwise stated, because copper-lime dusts had consistently given better results in past experiments than sprays and other dusts. More experiments were conducted on time, number and rates of applications and less on materials than in previous years. All materials were applied with hand dusters and sprayers.

1. Time of application. Copper-lime dust was applied to one series of plots at weekly intervals beginning May 25 when the blueberry plants were leafing out and coming into blossom, until June 22 about 10 to 12 days after blossom-fall. Each plot received one moderate application, that is, a sufficient amount to give the foliage a thorough but not heavy coverage. Beginning July 12, two days after the blossom-fall application, there were several days of heavy rainfall which may have increased the beneficial effects of that application.

All three early June applications gave good results, but the one at blossom-fall, as in previous years, was most beneficial. The three plots which received these applications showed a good retention of foliage through the season and the berries harvested were large. Adjacent untreated plots had practically no foliage, and produced berries a third smaller and a yield proportionally less at harvest time.

2. Rate of application. The amount of dust needed to give a certain degree of coverage to the foliage varied considerably because of the wind velocity and method of application but, rough-

ly, 18, 36 and 60 pounds of copper-lime dust per application per acre were used to give what were considered to be light, moderate, and heavy applications of dust, respectively. Two applications were made—on June 2 and June 10. The plots receiving moderate applications gave an increase in yield of 125 per cent, while those with light and heavy applications gave increases of 74 and 86 per cent, respectively.

3. Number of applications. Some plots were dusted on either June 2 or June 10 and others on both dates. The appearance of plants on all three sets of plots was much the same at the end of the season. The comparative yields of the one-application plots were higher. Due to variation in field conditions no conclusions were drawn.

4. Comparison of materials. The yield increases were somewhat greater on plots which had had applications of copper-lime dust containing 20 per cent monohydrated copper sulfate and 80 per cent lime, than on other plots which had received either a 25 per cent copper-lime dust or one containing 38 per cent copper sulfate, 14 per cent calcium arsenate and 48 per cent lime. This is in agreement with most previous results.

5. Year of treatment. Blueberry land is usually burned over one year, produces crops the following two years, and then is burned again. To 1933, inclusive, fungicidal treatments applied the year of burning had little effect on disease prevalence and yield the succeeding year. Treatment the year after burning often resulted in greater vigor and increased yields the next year provided that there was good disease control and no injury the year of application. Thus, in 1933, on plots burned in 1931 and dusted in 1932, the foliage developed earlier, the leaves were greener and more abundant, and the berries were larger and more numerous than on untreated checks. Dust applied to other plots in this same piece in 1933 only, gave good foliage-disease control but the plants remained less vigorous than those treated in 1932. These facts do not necessarily hold for a field that is in vigorous condition and yields a good second crop. Part of this field was also treated both in 1932 and 1933 with good results.

The percentage increase in yield of plants treated the second year of bearing over untreated checks was much higher than that for dusted plants bearing their first crop, but often, as in the pres-

ent case, the second crop is so small that the actual increase in yield is negligible.

In conclusion, experiments on control of foliage diseases on vigorous plants in Washington County showed that one or two applications of certain copper-lime dusts applied the year after burning near the time of blossom-fall usually result in sufficient increases in yield to make dusting pay.

EXPERIMENTS IN 1934

Experiments were continued in 1934 (25) with fungicidal dusts to control foliage diseases of low-bush blueberries. Comparisons were again made on the time and number of applications, on the year of treatment after burning, and on materials. The fungicides used were copper-lime dust and sulphur dust. They were applied with a hand duster.

As in previous years, copper-lime dust applied the year of burning had no noticeable effect.

Fungicides applied the year after burning, that is, on plants bearing their first crop, again resulted in yields being increased sufficiently to make dusting profitable. The average yield in bushels per acre from the plots receiving each treatment and from the corresponding untreated check plots is given in Table 1.

TABLE 1

Yields from Blueberry Plots Receiving Dust Treatments. 1934

Dust	Number of applications ¹	Yield of plots		Increase from dusting	
		Dusted	No dust	Bushels	Per cent
Copper-lime A ²	1	48	28	20	71
	2	76	31	45	147
" " B	1	50	29	21	75
	2	69	34	35	103
" " C	2	74	49	25	50
Sulphur	1	56	43	13	30
	2	67	30	37	122

¹ First and single applications were made near the time blossoms were falling, June 8-9, and the second application over three weeks later. Heavy showers followed the second application.

² Copper-lime dusts A, B, and C consisted of monohydrated copper sulphate, tricalcium arsenate and hydrated lime in the proportions 19-14-67, 38-14-48, and 25-0-75, respectively.

Copper-lime dusts had given good results every year. Sulphur dust had previously increased yields but had not particularly improved the appearance of foliage until 1934.

Plots burned in 1932 and treated in 1933 but not in 1934 yielded more in 1934 than the checks that had never been treated. Plots treated both in 1933 and 1934 showed further increases in yield. However, as in 1933, the second crop was so small that the actual yields were negligible. An example is given in Table 2 of a plot which was dusted in 1933 and part of which was dusted in 1934. Comparisons are made with a check plot which has never been treated. Yields are given in bushels per acre.

TABLE 2

Effect of Successive Years' Dusting

Year	Treated	Yield of the plots		Increase in yield of treated plot over the never-treated check	
		Treated	Check	Bushels	Per cent
1933	Yes	44	19	25	136
1934	Yes	1.87	0.67	1.20	178
1934	No	1.34	0.67	0.67	100

When different numbers of applications are compared it is seen that two applications of a fungicide gave better results than one. These results are shown in Table 1.

The time of application giving the best disease control was again at or following blossom-fall. Comparisons are based on yields of plots dusted at intervals of about a week from June 2 to July 3.

EXPERIMENTS IN 1935

During 1935 (24), using a hand duster as in past seasons, tests were continued on plots, each of one-thirty-sixth of an acre, comparing dates, numbers, and rates of applications, and kinds of materials. Some growers are equipped with power-driven dusters capable of blowing dust several hundred feet. Using a power-driven duster, mounted on a high chassis and horse drawn, plots of

one acre or more were treated with materials applied at different rates.

(a) Time and number of applications. One application of a copper-lime dust made on either June 13-14 or June 24 gave better results than one application made on either June 6 or July 2. Two applications made on June 13-14 and June 24, or three applications made on June 13-14, June 24, and July 2, gave the best results. This is shown in Table 3. All yields given are in bushels per acre. The figures in Table 3 show the same yields for the June 13 and the June 6 plots. However, the condition of the foliage, the greater retention of leaves, and other factors, indicate that June 13 was the better date.

TABLE 3

Results from Differences in Dates and Number of Treatments with Dust A,¹ with Average Yield of Untreated Plots 16 Bushels per Acre, 1935

Date	Yield	Increase from dusting		Appearance of plots	Rating
		Bushels	Per cent		
June 6	20	4	25	Poor	5
June 13	20	4	25	Good	4
June 24	22	6	37.5	Very good	3
July 2	18	2	12.5	Poor	6
June 13 and 24	30	14	87.5	Second best	2
June 13 and 24 and July 2	25	9	56	Best	1

¹ Dust A consisted of monohydrated copper sulphate, tri-calcium arsenate, and hydrated lime in the proportions 20-17.5-62.5.

TABLE 4

Results of Comparison of Fungicidal Dusts Applied June 13-14 and 24, with Average Yield of Untreated Plots 16 Bushels per Acre, 1935

Dust ¹	Yield	Increase from dusting		Appearance of plots	Rating
		Bushels	Per cent		
A	30	14	87.5	Very good	2
B	24	8	50	Good	3
D	21.4	5.4	34	Excellent	1
S	21.4	5.4	34	No improvement over untreated	4

¹ Materials A, B, and D contained monohydrated copper sulphate, tri-calcium arsenate, and hydrated lime, in proportions respectively as follows: 20-17.5-62.5, 38-14-48, and 25-25-50; material S contained 87 per cent sulphur and 10 per cent tri-calcium arsenate.

(b) Kinds of materials. Copper-lime dusts continued to be superior to sulphur dust. Single applications of sulphur dust on either June 13 or 24 gave poor results, which are omitted from the tables. Table 4 shows the plot-yields where two applications were made on the same dates using different materials.

TABLE 5

Results of Comparison of Rates of Application of Dust D,¹ Applied on June 16-17 and June 26 by Machine and on June 13-14 and 24 by Hand, 1935

Location	Method of application	Pounds of dust per acre per application	Yield in bushels		Increase from dusting		Appearance of plots	Rating
			Dust	No dust	Bushels	Per cent		
Ames	By machine	15	60	54	6	11	Little better than checks	4
Ames	Do	20	53	40	13	32.5	Better than checks	3
Nash	Do	20	37	36	1	3	No better than checks	5
Ames ²	Do	35	41	27	14	52	Good	2
Nash ³	Do	40	60.5	32	28.5	89	Excellent	1
Marston	By hand	11	25	16	9	56	Good	3
Marston	Do	20	42	16	26	163	Good to very good	1
Marston	Do	50	30	16	14	88	Good	2

¹ Dust D consisted of monohydrated copper-sulphate, tri-calcium arsenate, and hydrated lime, in the proportions 25-25-50.

² Harvested the day after rains broke the hot spell.

³ Harvested four days after rains broke the hot spell and after the berries on the dusted plots had regained much of their original volume. The berries on the untreated checks did not swell to any extent after the rains. The berries began to drop five or six days after the rains.

While the yield rate with dust D was no greater than that with S, D produced better results in that the leaves were retained to the extent of 83 per cent versus 58, and the weight of good berries was increased 93 per cent versus 35. ("Good" berries means those that were unshrunk and three-sixteenths inch or greater in diameter.)

(c) Rate of application. The results of comparisons of rates of application and of machine dusting and hand dusting, using the same material, are given in Table 5.

The results show that in 1935, 20 pounds of 25 per cent copper-lime dust per acre, used in a power duster, was not sufficient. An increase of 20 bushels per acre, obtained when 35 to 40 pounds per

acre was used, even under the severe drought conditions that existed, made the dusting commercially profitable.

RELATIONSHIP OF ARSENICAL INJURY TO FUNGICIDES

Many farmers attribute leaf injuries of all kinds on low-bush blueberries to "arsenical injury" from the application of tri-calcium arsenate dust to control the fruit fly. Close observation will show that the so-called "arsenical injury" is usually present before the arsenical dust is applied, and that the same injury occurs in areas that have never been dusted (24). Leaf injuries are attributable to several causes: (1) mechanical factors, (2) insects, (3) diseases, (4) arsenic, and (5) any of the first three aggravated by the presence of the arsenical dust. The most important causes of leaf injury on low-bush blueberries in Maine are considered to be, first, fungus diseases, and, second, the aggravation of previous injuries by the arsenical dust. This is not a condemnation of the use of an arsenical dust because when it is applied as recommended, and the leaves are free from injuries from other causes many growers get little or no appreciable injury from tri-calcium arsenate. This fact suggests the desirability of the prevention of injury to the leaves, in regions where it occurs, before the arsenical dust is applied. Certain localities, in particular those directly on the ocean shore in Washington County, may experience little leaf injury from any cause. In such places copper-lime dusts cannot be expected to improve the yields greatly.

Copper-lime dust applied at certain times, and under conditions of sufficient moisture on the leaves to "stick" the dust before wind or rains can remove it, will largely prevent the leaf diseases and injuries aggravated by tri-calcium arsenate. Its purpose is to control fungus diseases of the leaves. Its fungicidal value is enhanced by the addition of tri-calcium arsenate. Not only does the arsenical increase the fungicidal value but it also kills leaf-feeding insects. Two applications of copper-lime dust give good results when applied about a month earlier than the time for tri-calcium arsenate for fruit fly control. The time to apply copper-lime dust comes at blossom-fall and a week or ten days later. The foliage should be well covered with material at this time. The amount of copper-lime dust that gives the best results, when applied with a

hand machine, is about 35 pounds per acre of a dust containing 38 per cent monohydrated copper sulphate, or about 50 pounds per acre of a dust containing 20 per cent; that is, about 10 to 13 pounds of monohydrated copper sulphate per acre for each application. Copper-lime dust is considerably heavier than the arsenical dust and consequently more will be used to cover a given area.

RECOMMENDATIONS AS TO FUNGICIDES⁵

As shown above, experiments with fungicides on low-bush blueberries demonstrated that certain treatments controlled foliage diseases in some localities (Plate 15) and thereby improved plant yield and vigor (Plate 16). The experimental plots were located in North Gray, North Sedgwick, Jonesboro, and Columbia. The increases in yield from the use of fungicides were excellent except at North Sedgwick, where they were only fair to good because at that place there was less serious injury by the diseases under observation. However, there are many acres of good blueberry land away from the seashore where leaf injury and premature defoliation are caused by diseases. On such land dusting, as here recommended, is likely to be profitable.

Dust only the first crop unless a large second crop is produced. Successful results from dusting will not only increase the crop during the year in which it is applied, but a beneficial effect will be carried into the next season.

Dust twice: first, when about 80 per cent of the blossoms have fallen or a little later if there are no rains, and second, about 10-14 days after the first application. Copper-lime dust applications come about a month earlier than calcium arsenate dust for fruit fly control.

Dust should be applied when the air is still and the leaves are moist; the next best time would be during quiet weather before dew-fall. Dust should dry on leaves before a rainfall, because a considerable amount will adhere after once drying on. If it is impossible to dust before or between rains the dusting should be done as soon as possible afterwards. The dust should be applied in such a manner that the leaves will be evenly covered by a light, visible coating of dust.

⁵ From mimeographed circular by Florence L. Markin.

Copper-lime dust containing calcium arsenate has given best results. This dust is poisonous to bees. It is possible that large-scale dusting with this material in early or mid-June may cause considerable loss in pollinating insects. Our experimental work has been done on a small scale and no study has been made of the relationship of dusting to pollinating insects. If there is considerable bloom of any kind attractive to bees a grower may prefer to use a straight copper-lime dust particularly for the first application, although the results in yield will not be as high as with the copper-lime-arsenical dust. The Experiment Station has used the following straight copper-lime dust with good results

Monohydrated copper sulphate.....	25% (metallic copper 8.75+ %)
Hydrated lime.....	75%

Two suggestions are given for a copper-lime-arsenical dust:

1. Monohydrated copper sulphate.. 20% (metallic copper 7%)
 Tri-calcium arsenate 17% (metallic arsenic 6.5%±)
 Hydrated lime 63%
2. Monohydrated copper sulphate.. 25% (metallic copper 8.75%+)
 Tri-calcium arsenate..... 17% (metallic arsenic 6.5%±)
 Hydrated lime 58%

The dust can be purchased already prepared in approximately the above proportions, or the materials can be mixed at home. Purchase dust and dusting material from any reliable manufacturer or dealer in insecticides and fungicides. Copper-lime dust should be a light, dull grey in color and fine in texture (not caked). Only after becoming moist does the dust turn blue. It should be stored in tight containers in a dry place.

Apply dust at such a rate that about 10 pounds of monohydrated copper sulphate is used per acre with each application. For example, about 27 pounds of a 38 per cent dust, 40 pounds of a 25 per cent dust and 50 pounds of a 20 per cent dust will give this amount. (Here the percentage refers to proportion consisting of copper sulphate.) The two applications recommended will double the amounts used; thus, for example, 80 pounds of a 25 per cent dust would be used per acre during the season. Even though copper-lime dust is heavier than calcium arsenate and will

leave the duster at a greater rate, more time may be needed to apply it since the amount used is much greater. Adjustment of the duster may be necessary.

SUMMARY

A disease survey extending over several blueberry regions of Maine and through several seasons showed that witches' broom, leaf rust, and powdery mildew leaf-spot are often severely injurious to blueberry plants. Other diseases that are present but less important are the red-leaf disease, *Sclerotinia* shoot-blight and fruit-rot, *Botrytis* blossom-blight and fruit-rot, and brown leaf-spotting. The relative and actual importance of the different diseases varied from one region to another in the same season, and from one season to another in the same region.

Disease control without fungicides includes pruning, eradication, burning, and choice of resistant varieties and resistant wild clones. Fungicides of several types controlled foliage diseases and increased yields. Copper-lime dust proved generally better than the other fungicides, which included Bordeaux mixture, lime sulphur, sulphur, Oxo-Bordeaux, copper cyanamid, and copper carbonate.

The aggravation of slight previous leaf injuries by arsenical dust ranks next in importance to fungus diseases as a cause of leaf injury. Copper-lime-arsenic dust controls both fungus and insect injury better than either copper-lime or arsenical dust and thus indirectly also greatly reduces arsenical injury.

It is recommended that where diseases cause leaf injury and premature defoliation, copper-lime-arsenic dust be applied when about 80 per cent of the blossoms have fallen and again about 10 to 14 days after the first application. Certain conditions contribute to the effectiveness of such dusting.

LITERATURE CITED

1. Adams, J. F. Rusts on conifers in Pennsylvania. Penn. Agr. Exp. Sta. Bul. 160, pp. 3-30. 1919.
2. Arthur, J. C. Cultures of Uredineae in 1909. Mycol. 2:213-240. 1910.

3. Arthur, Joseph Charles. Manual of the rusts in United States and Canada. Lafayette, Ind. 1934.
4. Bailey, John S., Henry J. Franklin, and Joseph L. Kelley. Blueberry culture in Massachusetts. Mass. Agr. Exp. Sta. Bul. 358. 1939.
5. Bergman, H. F. Observations on powdery mildew on cultivated blueberries in Massachusetts in 1938. Phytopath. 29:545-546. 1939.
6. Boyce, John Shaw. Forest pathology. New York. 1938.
7. Brown, Nellie A. Blueberry galls produced by the fungus *Phomopsis*. Phytopath. 28:71-73. 1938.
8. Chandler, Frederick B., Irvin C. Mason, and Joseph A. Chucks. Blueberry investigations. Maine Agr. Exp. Sta. Bul. 360, pp. 184-185. 1931.
9. Clinton, G. P. Heteroecious rusts of Connecticut having a peridermium for their aecial stage. In Report of the Station Botanist for 1907; Part VI of the Biennial Report of 1907-1908. Conn. Agr. Exp. Sta. 1908. pp. 369-396.
10. Clinton, G. P. Notes on plant diseases of Connecticut. In Report of the Station Botanist for 1909 and 1910; Part X of the Biennial Report of 1909-1910. Conn. Agr. Exp. Sta. 1911. pp. 713-738.
11. Fraser, W. P. Collection of the aecial stage of *calyptospora columnaris* (Alb. & Schw.) Kühn. Science 30:814-815. 1909.
12. Fraser, W. P. Cultures of heteroecious rusts. Mycol. 4:175-193. 1912.
13. Fraser, W. P. Cultures of some heteroecious rusts. Mycol. 3:67-74. 1911.
14. Fraser, W. P. Further cultures of heteroecious rusts. Mycol. 5:233-239. 1913.
15. Fraser, W. P. Notes on *Uredinopsis mirabilis* and other rusts. Mycol. 6:25-28. 1914.
16. Hartig, Robert. Text-book of the diseases of trees. Translated by William Somerville, ed. by H. Marshall Ward. London. 1894.
17. Hilborn, M. T., and Florence L. Markin. List of Causes of fungous and bacterial plant diseases in Maine to 1936 inclusive. Plant Disease Reporter Supplement 105. Bur. Pl. Ind., U. S. Dept. Agr. 1938.
18. Hotson, J. W. A new species of *Exobasidium*. Phytopath. 17:207-216. 1927.
19. Lathrop, F. H., and C. B. Nickels. A comparative study of dusting by means of airplane and ground machine for the control of the blueberry maggot. U. S. Dept. Agr. Circ. 123. 1930.
20. Lathrop, F. H., and C. B. Nickels. The biology and control of the blueberry maggot in Washington County, Maine. U. S. Dept. Agr. Tech. Bul. 275. 1932.
21. Markin, Florence L. Blueberry diseases. Maine Agr. Exp. Sta. Bul. 360, pp. 204-206. 1931.
22. Markin, Florence L. Blueberry diseases. Maine Agr. Exp. Sta. Bul. 363, pp. 291-294. 1932.

23. Markin, Florence L. Blueberry diseases. Maine Agr. Exp. Sta. Bul. 369, pp. 577-581. 1933.
24. Markin, Florence L. Blueberry diseases. Maine Agr. Exp. Sta. Bul. 380, pp. 220-224. 1935.
25. Markin, Florence L. Diseases of the blueberry. Maine Agr. Exp. Sta. Bul. 377, pp. 389-391. 1934.
26. Markin, Florence L. Notes on blueberry diseases in Maine. Plant Disease Reporter 15:11-14. 1931.
27. Merchant, Charles H. An economic study of 239 blueberry farms in Washington and Hancock Counties, Maine. Maine Agr. Exp. Sta. Bul. 351. 1929.
28. Munson, W. M. The horticultural status of the genus *Vaccinium*. Maine Agr. Exp. Sta. Bul. 76. 1901.
29. Phipps, C. R. Blueberry and huckleberry insects. Maine Agr. Exp. Sta. Bul. 356. 1930.
30. Rhoads, Arthur S., George G. Hedgcock, Ellsworth Bethel, and Carl Hartley. Host relationships of the North American rusts, other than *Gymnosporangium*s, which attack conifers. *Phytopath.* 8:309-352. 1918.
31. Shear, C. L., Neil E. Stevens, and Henry F. Bain. Fungous diseases of the cultivated cranberry. U. S. Dept. Agr. Tech. Bul. 258. 1931.
32. Smith, Carl R. 1941 blueberry pack. Maine Dept. Agr. Mimeog. leaflet. 1941.
33. Stevens, Neil E. Notes on blueberry and cranberry diseases. *Proc. Amer. Cranberry Growers Assoc.* 55:7, 10. 1925.
34. United States Bureau of the Census. 16th census of the United States. 1940. Agriculture, vols. 1 and 3.
35. Weir, James Robert. Observations on *Calyptospora columnaris* and *Peridermium ornamentale*. *Mycol.* 18:274-277. 1926.
36. Wilcox, Marguerite S. *Diaporthe vaccinii*, the ascigerous stage of *Phomopsis*, causing a twig blight of blueberry. *Phytopath.* 30:441-443. 1940.
37. Wilcox, Marguerite S. Notes on blueberry fungi. *Plant Disease Reporter* 20:106-107. 1936.
38. Wilcox, Marguerite S. *Phomopsis* twig blight of blueberry. *Phytopath.* 29:136-142. 1939.



PLATE 1. Aecial stage of the witches' broom rust (*Calyptospora columnaris* Kühn) on lower surfaces of leaves of balsam fir (*Abies balsamea* (L.) Mill.) at Harrington, July 2, 1929.



PLATE 2. As Plate 1, except at Orono, April 5, 1932, as a result of inoculation, and in a less weathered condition.



PLATE 3. Perennial stage of witches' broom on part of a clump of low-bush blueberry stems (*Vaccinium pennsylvanicum* Lam.). Greenhouse, February 11, 1930.



PLATE 4. Three shoots containing the perennial stage of witches' broom (right), and healthy shoot (left), from "new-burn" low-bush land at North Sedgwick in July, 1929. Burning kills only the exposed stems, and new shoots from diseased clumps are more or less diseased.



PLATE 5. Perennial stage of witches' broom on most of the stems of a high-bush clump or crown (*Vaccinium corymbosum* L.) at East Lebanon, April 18, 1931.



PLATE 6. Perennial stage of witches' broom on various parts of a high-bush clump, mostly killed by the disease. Pea Cove, September 15, 1933.



PLATE 7. Prevalence of witches' broom on low-bush blueberries near forest containing the local alternate host (balsam fir). Stakes mark location of infected blueberry plants. North Sedgwick, November 9, 1932.



PLATE 8. Aecial stage of leaf rust (*Pucciniastrum myrtilli* Arth.) on lower surfaces of leaves of hemlock (*Tsuga canadensis* (L.) Carr.) at N. Sedgwick, June 25, 1929. Source of aeciospores used for successful inoculations of blueberry in the greenhouse.



PLATE 9. A, uredinial stage of leaf rust on low-bush blueberry leaves at Columbia, July 2, 1929. B, powdery mildew leaf spot (*Microsphaera alni* var. *vaccinii* (S.) Sal.) on low-bush blueberry (*pennsylvanicum* x *canadense*) at Robinson's Mills, July 1, 1929. C, powdery mildew white mycelium and black perithecia on low-bush blueberry (*pennsylvanicum*) at Cherryfield, September 25, 1929, enlarged 4X. Characteristic appearance from mid-August on.



PLATE 10. Shoots of low-bush blueberry with white mycelium of red-leaf fungus (*Exobasidium*) on the lower surfaces of the leaves (three shoots on left), and healthy shoot (on right), at N. Sedgwick, June 27, 1929.



PLATE 11. Low-bush shoot (left) defoliated and elongated by red-leaf disease, and healthy shoot (right), at Columbia, September 2, 1932.



PLATE 12. Low-bush blueberry with *Sclerotinia* shoot-blight, at N. Sedgwick, June 11, 1929.



PLATE 13. A brown leaf spot (*Septoria*) on low-bush blueberry at Columbia, July 1, 1929.



PLATE 14. A brown leaf spot (*Septoria*?) on low-bush blueberry at Harrington, September 21, 1929.

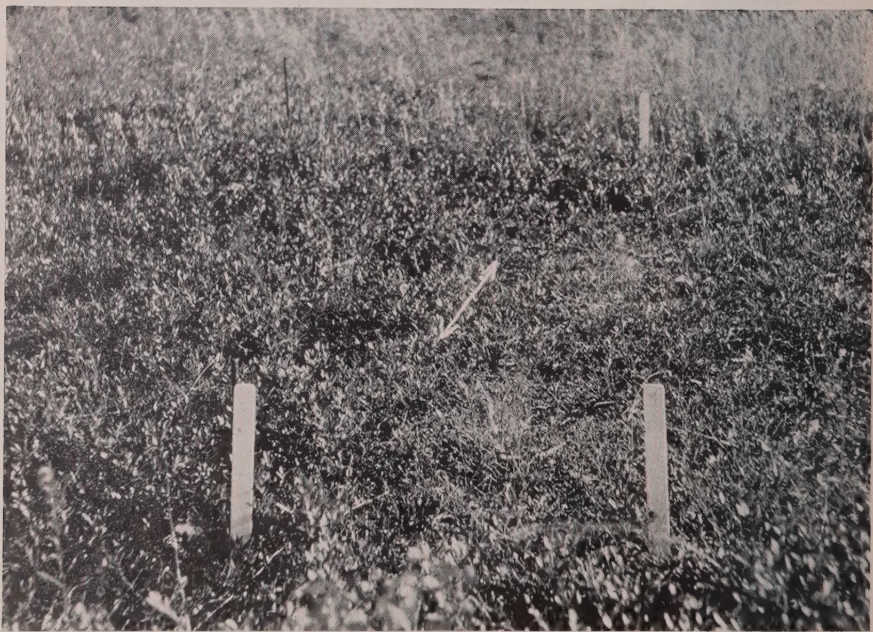


PLATE 15. Low-bush blueberry spray plots at Harrington, September 20, 1929. The white arrow indicates the line dividing a patch with unsprayed plants to the right defoliated by disease and Bordeaux-sprayed to the left with leaves still adherent.



PLATE 16. Low-bush blueberry shoots that fairly represent (on left) plants dusted twice with copper-lime dust and (on right) plants of same original patch as the dusted plants but just outside the dusted area and with leaves fallen and fruits undeveloped because of foliage diseases. Columbia, August 30, 1932.

